Research Article

Integration of Mineral Fertilizer and Poultry Manure for Improving Soil Health and Maize Growth under Calcareous Soil Environment

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Abstract | Pakistani soils are deficient in organic matter. Organic matter in the soil affects soil properties and processes. The adequate carbon level of the soil is 1.29 % but in Pakistani soils carbon is less than the adequate level because of high temperature and low rainfall. Different sources of organic matters such as farm yard manure, poultry waste, rice husk etc. can increase productiveness of soil. Combined usage of poultry waste material and chemical fertilizer improved maize growth and health of soil. This experiment comprised of 11 treatments applied under completely randomized design like, T1 = chemical fertilizers at recommended rate, T2 = chemical fertilizers at half recommended rate, T3 = waste of poultry at the rate of 5 ton/ha, T4 = waste of poultry at the rate of 7.5 ton/ha, T5 = waste of poultry at the rate of 10 ton/ha, T6 = T1 + T3, T7 = T1 + T4, T8 = T1 + T5, T9 = T2 + T3, T10 = T2 + T4 and T11 = T2 + T5. At maturity and different agronomic and yield parameters were recorded before harvesting maize plants. Laboratory analysis for collected soil samples was carried out. Data were statistically analyzed. Results indicated that treatment (T8) produce maximum plant height (115.0 cm), biomass (64.34 g) and root length (27.083 cm) of maize. Organic matter content (1.78 %), phosphorus (16.67 ppm) and potassium (213.0 ppm) concentration in soil was also increased in this treatment.

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Keywords | Maize, Poultry manure, Mineral fertilizer, Yield parameters, Soil health parameters

Introduction

In Pakistan, maize is the most significant crop next rice and wheat. Maize is called "king of grain crops". Its average production is 3428 kg ha^{-1} (Anonymous, 2008). Along with grains it is also grown for fodder (Khaliq et al., 2004). In Khyber Pakhtunkhwa (KPK) it is cultivated in 55.01 % of the total area with 63.01 % of yield production whereas in Punjab30-35% yield is achieved from 38% of the total area. In Sindh and Baluchistan, it is produced with 3% and 5% yield of the total cultivated area (GOP, 2015). Maize production in 2010 in Pakistan was 36581000 tons from 9 lac 81 thousand ha. Maize grains are the source of minerals, vitamins and ashes. It contains fats (5.8%), proteins (10%), starch (72%), sugar (3%) and burning ash (1.7%). It is used for the production of cosmetics, flakes, syrup, alcohol, starch and fats. The origin of maize plant is exotic South USA (Chaudhary et al., 2014). Pakistani soils are

degraded day by day due to inadequate management and fertilizer application. These soils are deficient in organic matter due to aridity factor of area. Mostly Pakistani soils have less than 1% organic matter. Imbalanced fertilizers application adversely affects plant growth and efficiency. Plant response to applied fertilizer depends on nutrient status of the soil. Fertilizer imbalance is associated with a number of factors like unavailability at proper time and higher charge. Improper fertilizer application also pollute atmosphere (Oad et al., 2004; Prabhu et al., 2003). Organic manure enhances soil fertility and increase plant growth as a supplement of manures due to provision of various nutrient and chelating effect on cations by normal acids (Mohanty et al., 2006). They improve the nutrient position of the soil that led to increase availability of nutrients in soil. People prefer goods obtained by organic farming because of their purity, uncontaminated and less adversely affective to health (Gorttappech et al., 2000).

Addition of various organic amendments improved the maximum height of rice-wheat. The use of compost proved to be superior to that of Sesbania and Farm Yard Manure (FYM) green manure. This tendency to increase the height of the plant increased when the chemical fertilizer was combined with these organic materials. The combination of fertilizers and compost at the highest rate (10 ton/ha) was the most successful treatment (Sarwar, 2005). Similarly, combining both amounts of compost + chemical fertilizers caused maximum agglomeration in rice-wheat plants compared to FYM and Sesbania. Using FYM proved to be superior to control and led to a substantial rise in the number of rice-wheat crops growers. A comparison of compost and fertilizer proved the superiority of compost over chemical fertilizer in this regard, but combination of these proved to be more successful than using compost alone (Sarwar et al., 2007).

Combined usage of carbon-based manures like waste cow dung, poultry manure, residues of harvested crops and green manure crops with mineral fertilizer is the best way to manage nutrients in soil (Antil, 2012). This also improves soil fertility, conserve soil and reduce environmental pollution. Considerable usage of different nutritional sources proved important for increasing demand of crop production and sustainable agriculture (Korsaeth et al., 2002). An increase in rice and wheat production was achieved when mineral fertilizers was coupled with different sources of organic materials (Sarwar et al., 2020).

Materials and Methods

A research trail was conducted in pots to determine combined outcome of mineral fertilizer and poultry manure on fertility status of soil after growing maize. Samples of soil were taken for determination of various laboratory parameters before starting experiment (Table 1). After analysis, pots were filled with ten (10) kg soil and irrigated by ground water. Completely randomized design was applied to arrange the pots. Current experiment included 11 treatments and 3 replications.

Treatments

T_1= Chemical fertilizers at recommended rate; T_2= Chemical fertilizers at half recommended rate; T_3= Waste of poultry at the rate of 5 ton/ha; T_4= Waste of poultry at the rate of 7.5 ton/ha; T_5= Waste of poultry at the rate of 10 ton/ha; $T_6 = T_1 + T_3$; $T_7 = T_1 + T_4$; $T_8 = T_1 + T_5$; $T_9 = T_2 + T_3$; $T_{10} = T_2 + T_4$; $T_{11} = T_2 + T_5$.

Maize variety (FM3) taken from Ayyub research institute was used as test crop. Poultry manure was applied according to treatments. Initially five seeds were sown per pot and after germination three plants were maintained. Crop was harvested at maturity. Post soil analysis was done by collecting samples from each pot. Urea, SSP and potassium sulfate were applied as sources for NPK. Recommended rate of NPK used in this study was N = 225, P_2O_5 = 100 and K_2O = 100 kg ha^{-1}, respectively.

Analytical methods for soil analysis

Analytical methods for laboratory determinations were used as given in Hand Book No. 60 of USDA (1969).

Soil organic matter

For organic matter determination Method 24 was used.

Available phosphorus

It was determined by Olsen's method (Tandon, 2011).

Soluble potassium

Soluble potassium was determined by (Method 11a).

Statistical analysis

Statistics 8.1 software was used for the statistical

analysis. ANOVA was made for different parameters (Steel et al., 1997).

Table 1: *Soil Characteristics used in experiment.*

Characteristics	Unit	Value
Saturation percentage	%	
pH_s	-	7.50
EC_e	dS m^{-1}	1.78
CO_3	me L^{-1}	3.60
HCO_3	me L^{-1}	6.30
Cl	me L^{-1}	4.10
SO_4	me L^{-1}	3.80
Ca + Mg	me L^{-1}	4.50
Na	me L^{-1}	10.8
SAR	-	7.20
Sand	%	45.1
Silt	%	26.8
Clay	%	28.1
Textural class	_	Sandy clay loam

Results and Discussion

Plant height of maize

Height of plants is the most important parameter that reflects crop productivity. All the treatments significantly affected this parameter of plant height (Figure 1). Extreme height of plants (115 cm) was observed in treatment T_8 (T_1+ T_5). It significantly differed from T_7 (111.7cm) and T_{11} (107.9 cm). Inferior results were obtained in T_3 (waste of poultry at the rate of 5 ton/ha) when linked by all other treatments. Kibria et al. (2013) observed that joined usage of poultry manure waste plus chemical fertilizer not only increased yield but also plant growth. The integration of poultry manure with inorganic source also improves the availability of nutrient to maize and its use efficiency (Ayeni and Adetunji, 2010).

Total biomass of maize plants

Biomass is vital parameter for fodder crops that indicate yield of crops. Total biomass of the maize crop was greatly affected by usage of poultry waste alone and in mixture with chemical fertilizers. Statistically all treatments showed significant difference on total biomass of maize crop (Figure 2). The treatment T_3 remained inferior when compared with T2 in terms of statistics. Maximum biomass of maize (64.34 g) was produced by T_8 (T_1 + T_5). Treatments T_7 (58.67 g) and T_6 (55.67 g) followed the treatment T_8. Variances amongst these 03 treatments were non-significant statistically. Collective usage of poultry waste and mineral fertilizers improved maize growth and yield (Khaliq et al., 2004). Similarly, Boateng et al. (2006) observed an increase in maize biomass by addition of organic source like manure of poultry waste material.

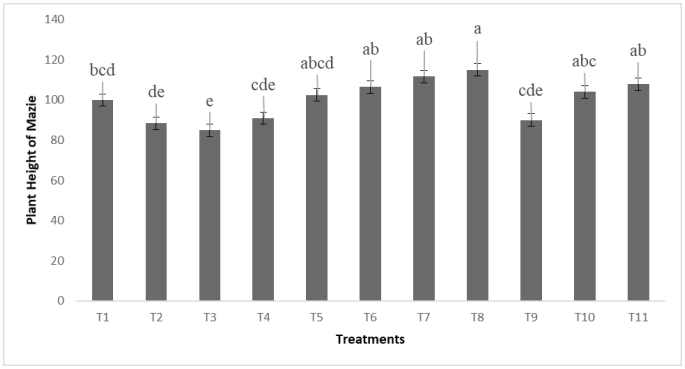

Figure 1: *Combined effect of mineral fertilizer + poultry dung on maize height.*

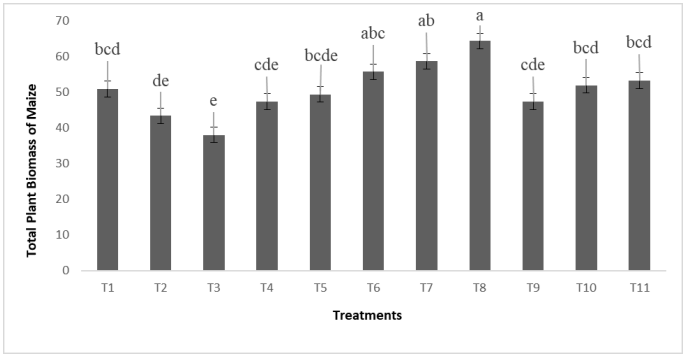

Figure 2: *Combined effect of mineral fertilizer + poultry dung on maize biomass.*

Maize root length

Plant roots are the most important part on which growth of plants depends. Poultry manure and inorganic fertilizer application to maize plant affected root length of maize plants (Figure 3). Maximum root length measured in treatment T_8 (T_1 + T_5) was 27.08 cm. The treatments T_7 (24.58 cm) and T_{11} (22.25 cm) followed the T_8. The minimum root length (11.66 cm) was noted in treatment T_3. The treatments T_2 (12.5 cm) and T_4 (13.75 cm) remained at par statistically. These outcomes were in accordance of the findings of Shah et al. (2007). They determined improved root length in maize when fertilized with poultry manure and inorganic nitrogen fertilizer.

Organic matter in soil

Organic matter has a significant part in soil fertility. Carbon-based manures are nutritious supplement used to increase soil organic matter. Almost all soil properties depend on organic content present in soil. Soil fertility was significantly exaggerated by

the incorporation of carbon-based manures (Figure 4). The treatment T_2 remained most inferior where just organic form of nutrients was added. Maximum organic matter content was observed in treatment T_8 (0.72%). Treatment T_8 significantly differs from T_7 when compared in terms of statistics. The treatment T_1 with a value of 1.78 % organic matter was next to T_2.

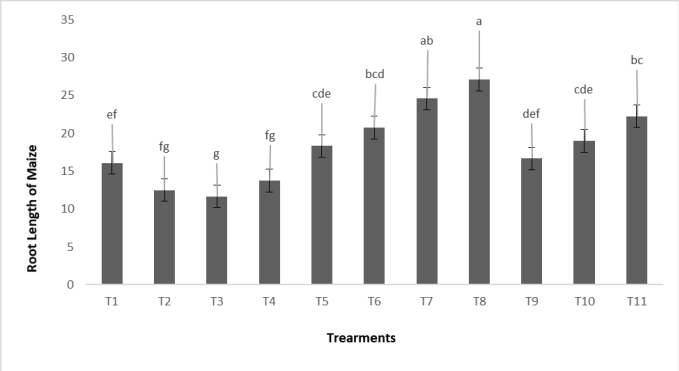

Figure 3: *Combined effect of mineral fertilizer + poultry dung on maize root length.*

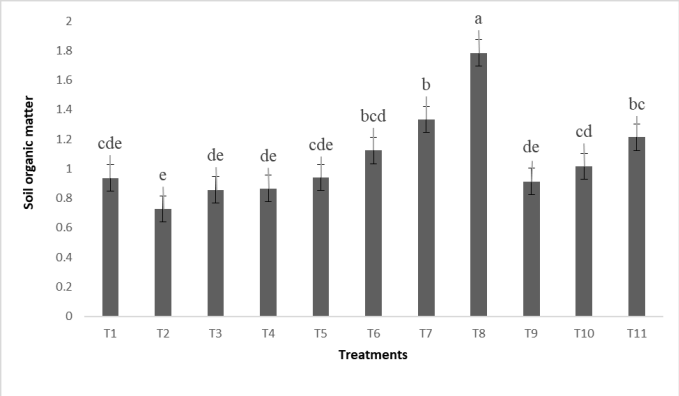

Figure 4: *Combined effect of mineral fertilizer + poultry dung on soil organic matter.*

Sarwar et al. (2008) revealed that incorporation of carbon-based manure with mineral fertilizers was a good technique to enhance fertility of soil. When carbon-based manure is used with mineral fertilizers, it enhanced its efficiency and productivity in sustainable agriculture. Addition of poultry manure increased nitrogen content in the soil. This content can be further increased by using chemical fertilizer along with poultry dung. Development, quality and produce of maize crop can be increased by using organic and inorganic sources of fertilizers (Boateng et al., 2006).

Phosphorus in soil

Phosphorus is 2nd maximum plentiful element on earth surface. Its availability is highly dependent on soil pH and calcareousness. It is an important element required for plants growing. Phosphorus has a constitutional character in ATP molecules besides nucleic acid. It enhances crop maturity. Poultry manure is not only a good source of phosphorus but also increase availability of phosphorus in the soil. All the treatments significantly affect the phosphorus content of the soil (Figure 5). Extreme P concentration was noted in treatment T_8 (chemical fertilizers at recommended rate + waste of poultry at the rate of 10 ton/ha). Phosphorus concentration in T_1 and T_2 treatment was recorded as 8 and 5 ppm respectively. Minimum value of soil phosphorus was determined in T_2 where ½ of recommended dose of chemical fertilizer was used. All other treatments significantly differ from each other. These discoveries were in line with conclusions of Friend et al. (2006). Similarly, McGrath et al. (2009) also noted that all types of soil properties (physical, chemical and biological) were upgraded by usage of poultry dung.

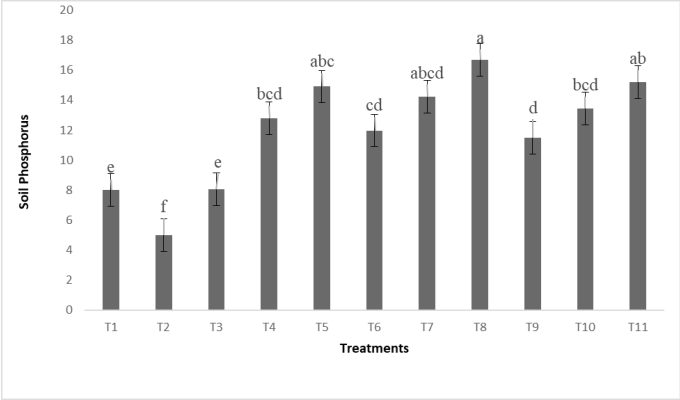

Figure 5: *Combined effect of mineral fertilizer + poultry dung on soil phosphorus.*

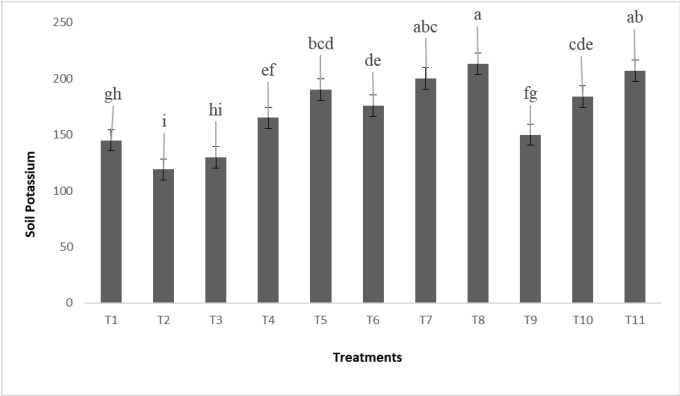

Figure 6: *Combined effect of mineral fertilizer + poultry dung on soil potassium.*

Potassium in soil

Potassium stands as an enzyme activator and third most abundant element. Soil potassium in experiment is significantly affected by all the treatments. Highest value of soil potassium was recorded in treatment T_8 (T_1 + T_5) with a value of 213 ppm (Figure 6).

Whereas, minimum concentration was observed in treatment T_2 (half recommended NPK) with a value of 119 ppm. Treatment T_1 was next to T_2 with value of 145ppm. Both these treatments were significantly different. Likewise, T_3 (waste of poultry at the rate of 5 ton/ha) and T_4 (waste of poultry at the rate of 7.5 ton/ha) remained statistically significant. These results are supported by the observations of Guo and Song (2009). They observed an improvement in nutrient status of soil with the use of poultry dung.

Conclusions and Recommendations

It was concluded from current experiment that combined/integrated used of mineral fertilizers coupled with poultry dung at the rate of 10 ton/ha remained most superior treatments to all others for boosting of maize yield and maintenance of soil fertility (organic matter, phosphorus and potassium status). Hence, it is recommended to farmers that they should integrate poultry dung or waste material with chemical fertilizers to boost up crop yield and maintenance of soil health.

Novelty Statement

Usage of poultry dung improve maize yield and maintains soil health.

Author's Contribution

Muhammad Fiyyaz: Conception and design of the work and conduction of experiment.
Ghulam Sarwar: Academic supervisor.
Noor-us-Sabah: Drafting and technical assistance.
Mukkram Ali Tahir: Co-supervision and technical assistance at every step.
Muhammad Aftab and Sarfraz Hussain: Interpretation of data and excel work for graphs making.
Muhammad Zeeshan Manzoor and Ayesha Zafar: Helped in lab. work and write up.
Imran Shehzad and Aneela Riaz: Statistical analysis and Proof reading and final editing.

Conflict of interest

The authors have declared no conflict of interest.

References

Anonymous, 2008. Agricultural Statistics of Pakistan. Government of Pakistan, Ministry of Food, Agriculture and Livestock (Economic Wing), Islamabad.

Antil, R.S., 2012. Integrated plant nutrient supply for sustainable soil health and crop productivity. A. Kumar (Eds) vol. 3. Focus Global Reporter, 2012.

Ayeni, L. and M. Adetunji. 2010. Integrated application of poultry manure and mineral fertilizer on soil chemical properties, nutrient uptake, and yield and growth components of maize. Nat. Sci., 8(1): 60-67.

Boateng, S.A., J. Zickermann and M. Kornahrehs. 2006. Poultry manure effect on growth and yield of maize. J. Appl. Ecol., 9: 2006. https://doi.org/10.4314/wajae.v9i1.45682

Chaudhary, D.P., S. Kumar and S. Langyan. 2014. Maize: Nutrition dynamics and novel uses. Springer New Delhi, Heidelberg, New York, Dordrecht, London. https://doi.org/10.1007/978-81-322-1623-0

Friend, A.L., S.D. Roberts, S.H. Schoenholtz, J.A. Mobley and P.D. Gerard. 2006. Poultry litter application to Loblolly pine forests: Growth and nutrient containment. J. Environ. Qual., 35: 837-848. https://doi.org/10.2134/jeq2005.0244

GOP, 2015. Ministry of Food, Agriculture and Livestock (MINFAL), Govt. of Pakistan.

Gorttappech, A.H., A. Ghalavand, M.R. Ahmady and S.K. Mirnia. 2000. Effect of inorganic and organic fertilizer on quantitative and qualitative traits of different cultivars of sunflower (*Hellianthus annus* L.). Ir. J. Agric. Sci., 6(2): 85-104.

Guo, M. and W. Song. 2009. Nutrient value of alum-treated poultry litter for land application. Poult. Sci., 88: 1782-1792. https://doi.org/10.3382/ps.2008-00404

Khaliq, T., T. Mahmood and A. Masood. 2004. Effectiveness of farmyard manure, poultry manure and nitrogen for corn (*Zea mays*) productivity. Int. J. Agric. Biol., 2: 260-263.

Kibria, M., N. Hossain, M. Ahammad and K. Osman. 2013. Effects of poultry manure, kitchen waste compost and NPK fertilizer on growth and yield of ladies finger. IOSR J. Environ. Sci., Toxicol. Food Technol., 2(6): 55-60. https://doi.org/10.9790/2402-0265560

Korsaeth, A., T.M. Henriksen and L.R. Bakken. 2002. Temporal changes in mineralization

and immobilization of N during degradation of plant material: Implications for the plant N supply and N losses. Soil Biol. Biochem., 34: 789-799. https://doi.org/10.1016/S0038-0717(02)00008-1

McGrath, S., R.O. Maguire, B.F. Tacy and J.H. Kike. 2009. Improving soil nutrition with poultry litter application in low input forage systems. Agron. J., 102: 48-54. https://doi.org/10.2134/agronj2009.0198

Mohanty, S., N.K. Paikaray and A.R. Rajan. 2006. Availability and uptake of phosphorus from organic manures in groundnut (*Arachis hypogea* L.) corn (*Zea mays* L.) sequence using radio tracer technique. Geoderma, 133(3): 225-230. https://doi.org/10.1016/j.geoderma.2005.07.009

Oad, F.C., U.A. Buriro and S.K. Agha. 2004. Effect of organic and inorganic fertilizer application on maize fodder production. Asian J. Plant Sci., 3: 375-377. https://doi.org/10.3923/ajps.2004.375.377

Prabhu, T., P. Narwadekar, A. Sannindranath and M. Rofi. 2003. Effect of integrated nutrient management on growth and yield of okra (*Abelmoschus esculentus* L. Moench) cv. Parbhani Kranti. Orissa J. Hortic., 31(1): 17-21.

Sabah, N.U., G. Sarwar, M.A. Tahir and S. Muhammad. 2016. Comparative efficiency of high (triple super phosphate) and low (rock phosphate) grade P nutrition source enriched with organic amendment in maize crop. Pak. J. Bot., 48(6): 2243-2248.

Sabah, N.U., G. Sarwar, M.A. Tahir and S. Muhammad. 2018. Depicting the role of organic amendments for bio available phosphorus release from different sources of rock phosphate and uptake by maize crop. Pak. J. Bot., 50(1): 117-122.

Sabah, N.U., G. Sarwar, M.A. Tahir and S. Muhammad. 2018. Evaluation of dewaxed filter cake press mud for p-release from indigenous rock phosphate and its utilization by maize. Pak. J. Agric. Sci., 55(2): 361-366.

Sarwar, G., 2005. Use of compost for crop production in Pakistan. Ökologie und Umweltsicherung. 26/2005. Universität Kassel, Fachgebiet Landschaftsökologie und Naturschutz, Witzenhausen, Germany.

Sarwar, G., H. Schmeisky, N. Hussain, S. Muhammad, M. Ibrahim and E. Safdar. 2008. Improvement of soil physical and chemical properties with compost application in Rice-Wheat cropping system. Pak. J. Bot., 40(1): 275-282.

Sarwar, G., M.A. Malik, N.S. Sabah, M.A. Tahir, M. Aftab, M.Z. Manzoor and A. Zafar. 2020. Comparative efficiency of compost, farmyard manure and sesbania green manure to produce rice-wheat crops under salt stressed environmental conditions. J. Pure Appl. Agric., 5(3): 33-42.

Sarwar, G., N. Hussain, H. Schmeisky and S. Muhammad. 2007. Use of compost an environment friendly technology for enhancing rice-wheat production in Pakistan. Pak. J. Bot., 39(5): 1553-1558.

Shah, Z., Z. Shah, M. Tariq and M. Afzal. 2007. Response of maize to integrated use of compost and urea fertilizers. Sarhad J. Agric., 23(3): 667-673.

Steel, R.G.D., J.H. Torrie and D.A. Dicky. 1997. Principles and procedures of statistics: A biometrical approach. 3rd ed. McGraw-Hill Book Int. Co., Singapore.

Tandon, H.L.S., 2001. Methods of analysis of soils, plants, waters and fertilisers. Fertiliser Development and Consultation Organisation 204-204A Bhanot Corner, 1-2 Pamposh Enclave New Delhi-110048, India.

U.S. Salinity Laboratory Staff. 1969. Diagnosis and Improvements of saline and alkali soils. Handbook No. 60. USDA. U.S. Govt. Printing Office, Washington, DC, USA.